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2.—*Major Sim's Report.*

THE distance between Point Ramen, or Tonnetory, in the Ramnad province, and the opposite coast of Ceylon, is about sixty-two miles. In the intervening space are situated the islands of Ramisseram and Manar, separated from each other by the bank called Adam's Bridge, and from the coasts of Ramnad and Ceylon by the narrow channels or straits of Paumbum and Manar.

The Manar channel is about a mile in breadth, and separates the island of Manar from Ceylon. It is navigable for small dhonies only, and country boats. The island of Manar, which is a dependency of Ceylon, extends about twenty miles across the Straits in a north-west direction. At its west end commences Adam's Bridge, which runs about thirty miles also in a north-west direction to the island of Ramisseram. This island is about ten miles in length, and is separated from the coast of Ramnad by the channel of Paumbum, a mile and a quarter in width.

The Manar channel was surveyed, under instructions from the Ceylon government, by the late Captain Dawson of the Royal Engineers, and Mr. Stewart, the master-attendant of Columbo, who describe it as a long, narrow, and very winding channel, having about six feet of water in the shallow parts, with the exception of a bar opposite to its south end, on which there is not more than three or four feet of water. This channel, from the account given of it by the officers who surveyed it, does not appear to be capable of any material improvement.

The bank of Adam's Bridge is a very extraordinary formation. It is only about a quarter of a mile in breadth, and consists entirely of sand, partly above and partly below water, collected apparently by the surf and currents, and unsupported, as far as could be ascertained, by rock. The east end of it was pierced by the Ceylon officers to the depth of thirty feet, and nothing found but sand. On each side of the bank, at the distance of two and a half or three miles, the sea is six fathoms deep, and quite free from obstructions of every kind.

There are three principal openings or channels across the bank: one near the island of Manar, called the Tal Manar Passage; the second eight miles farther to the west; and the third about eleven miles from the island of Ramisseram, termed the Tanny Coody Passage. This last was examined and surveyed on the present occasion. It is narrow in the centre, and thirty feet deep, with broad curved bars opposite to its two ends, on which there is not more than five or six feet of water. The bank between it and Ramisseram is entire, and several feet above water. The Tal Manar Passage was examined by the Ceylon officers, and re-

sembles exactly that of Tanny Coody, but is not so deep, there being only about three feet of water on its northern bar. The intermediate opening was not examined; but from its appearance, as well as from the description given of it by the fishermen who frequent the place, there can be no doubt of its corresponding very nearly with the other two. It is said to be rather deeper than the Tal Manar Passage, but not quite so deep as that of Tanny Coody.

In the vicinity of the Tal Manar and Tanny Coody openings the bank is visible above water for several miles, intersected by only a few narrow openings, but towards its centre it is chiefly covered with water, and very little sand is to be seen, though, from the surf breaking exactly on the line of the bank, the depth of water cannot exceed a few feet.

During both monsoons, on the lee side of the bank, to the distance of from half a mile to a mile, there are a great number of irregular shifting sand-banks scattered about, on which there are from two to four feet of water, with passages between them, eight or nine feet deep. The weather side, on the contrary, particularly towards the end of the monsoon, is, in a great measure, clear of such banks, and the surf breaks on its shore nearly in a straight continued line. When the monsoon changes, the strength and prevailing direction of the currents change too, and the loose sand, of which the shifting banks are composed, on what was the lee side, being stirred up by the surf and sea, is swept by the current through the channels, and deposited on the opposite side, partly on the bars, and partly on loose detached heaps along the bank. These deposits appear to be further increased by the sand thrown up on the weather shore by the surf, which, as soon as it becomes dry, is carried by the wind across the bank into the sea on the other side. It was observed, when the wind was tolerably strong, that a continued stream of sand was swept across the bank into the sea on the lee side. The beach of Adam's Bridge, therefore, to the distance of about a mile on both sides, is continually changing and shifting. On the weather side it is generally clear, except immediately opposite to the channels where there are always projecting bars, while, on the opposite side, there are many loose banks scattered about, and constantly changing and varying in position and extent as the monsoon advances, and according to the state of the sea and weather.

During both monsoons, rather a high surf breaks on the weather side of the bank, but the south-west monsoon produces much the highest surf, accompanied by a long heavy swell. During part of the north-east monsoon, the surf breaks on both sides of the bank.

Dhonies in ballast and fishing-boats occasionally pass through

the openings in fine weather, but the passage is attended with some difficulty and danger, and is not common.

There is an account, I was informed, given in the records of the Dutch government of Ceylon, of a Dutch fleet having, on one occasion, escaped from a Danish fleet by passing through the channels of Adam's Bridge. If this be authentic, either some of the channels must have been deeper in former days, or the ships must have been of a small size. It is probable, indeed, that the depth and extent of the openings are constantly changing from the effect of the currents and surf, and the quantity of loose sand about the bank, and that they will not be found of the same size for any length of time; they appear to be affected by every change in the weather, the currents and surf, and most likely vary considerably in different seasons.

If it be possible to obtain any where through the Straits a channel sufficiently deep for all classes of ships, it must, I think, be sought for in some part of this bank; and even here the practicability of opening such a channel, and of keeping it open, is very doubtful. A strong double bulwark of stones across the bank, extending into deep water on both sides, with a narrow opening of one hundred or two hundred feet, might, I think, with reason be expected to accomplish the object. The velocity of the current would probably keep a narrow fixed channel of that description always sufficiently deep, and sweep off any sand that might be carried into it either by the sea or by the wind; and as the bulwark would extend into deep water beyond the shifting sands and the influence of the surf, there would be *little risk*, I think, of its ends being filled or choked with sand. The danger to be chiefly apprehended is the formation of bars opposite to the ends of the channel, similar to what are now found in front of the natural openings, particularly on the south side, where, from the superior strength of the south-west monsoon and heavy swells, sand-banks are always the largest and most numerous; but of this I think there would not be much risk: the quantity of sand carried through the channel, from its being beyond the influence of the surf, would probably not be very great, and as the current would be rapid and extend into deep water, it is likely that what did pass through it would be dissipated, and disappear.

The cost of such a work would, however, be very great indeed, and could only be justified by its being considered an object of high national importance to have a passage sufficiently deep in time of war for the largest vessels. In the event of a struggle for the superiority at sea with an European enemy, the advantages of such a channel would be invaluable; but it is doubtful whether the benefits which commerce would derive from it, great as they undoubtedly would be, would warrant an undertaking, the expense

of which, under the most favourable circumstances, must be very large, and the success, from a variety of causes which neither can be foreseen nor guarded against, uncertain.

There remains to be considered the Paumbum Channel or Strait between Ramisseram and the Ramnad coast, which affords perhaps the only prospect of a moderately deep channel, such as would benefit commerce generally, and the coasting trade of India in particular, without the necessity of incurring a very large or disproportionate expenditure.

The examination of the Paumbum Passage has accordingly, and in conformity with the instructions of Government, occupied the whole of the attention and time of the officers deputed for the purpose of surveying the Straits, with the exception of a few days devoted to the inspection of Adam's Bridge.

The obstacles to be overcome at Paumbum are a dam or ledge of rock extending from the island of Ramisseram to Point Ramen or Tonnetory, on the opposite coast of Ramnad, and an irregular sand-bank a little to the south of it, the exact situation and shape of which will be readily understood from an inspection of the accompanying maps, on which the dam and sand-bank, with the soundings in their vicinity, are minutely and accurately expressed.

The dam is 2250 yards in length, and runs east and west. It is bounded by two parallel ridges of rock, about one hundred and forty yards apart. The north ridge is considerably the highest, and is termed the first or great dam. It is in most places visible at low water, though nowhere sufficiently connected to prevent entirely, at any time, the passage of the water. The line of the south ridge or dam can also be distinctly traced at low water, but only a few detached rocks on it even then appear above water. The whole or greater part of the space between these two ridges is filled up by large irregular masses of rock, in various positions, but generally in directions nearly parallel to the principal ridges, and usually several feet lower than them.

The continuation of the rock or dam can be readily traced on the main land and island of Ramisseram, in its natural position, and in uniform layers, having a small inclination to the south, preserving exactly the same direction, but on both sides several feet higher than the dam. The ridges which form the dam are very much broken and displaced, and now consist of large flat masses of rock, seldom more than two or three feet in thickness. Their shattered state, and the break or chasm which they form in the general height of the stratum of rock, clearly indicate that the island of Ramisseram was at one time connected with the main land, and that it has been separated, in the first instance, by the sea, during storms breaking over and bursting the chain of rocks which joined them; and, afterwards, by the water undermining

and displacing the broken fragments. This supposition is confirmed by the records of the Pagoda of Ramisseram, which relate that, until the early part of the fifteenth century, the island was connected with the continent by a narrow neck of land; and that the Sawmy of Ramisseram was carried across to the main land three times every year, on particular festivals. During the reign of Achoodapah Naig, rajah of Madura, about the year 1480, a small breach was made, by a violent storm, in the land which formed the junction; but as there was no great depth of water on it, travellers continued to cross on foot till the time of his successor, Vessoovanada Naig, when the breach was much enlarged by a second storm. The opening was filled up and repaired, to facilitate the passage of the pilgrims to the Pagoda of Ramisseram; and the repairs lasted about ten years, when a third hurricane destroyed them, and greatly extended the breach, after which no attempt was made to fill up the chasm. Since then, every succeeding storm has assisted in destroying and undermining the dam; and the inhabitants believe that its destruction is still proceeding, and that fifteen or twenty years make a sensible alteration in it. They state that a storm occurs generally once in that period, and always displaces and washes away a portion of the rock.

Besides the ridges of rock which constitute the dam, and which, as already stated, are about one hundred and forty yards in breadth, rocks and stones, mixed with sand, form the bottom, to a distance of about eight hundred yards on the north side of the dam, and two hundred yards on the south side. Beyond eight hundred yards, the bottom to the north consists of mud and clay, with fourteen feet of water; and on the south side, beyond the rocks, it is soft mud and sand.

From a careful examination of the ground on the north side of the dam, by means of iron probes, and from the appearance of the beach on the Ramisseram and Ramnad coasts, it is probable that no connected layers or beds of rock extend farther than one hundred and fifty or two hundred yards from the dam; and that beyond this distance, the bottom consists of detached fragments of rock and stones, mixed with hard gravel and sand. The bottom on the south side is similar, being composed partly of beds of rock and partly of loose fragments.

The ledges of rock which form the dam, and the strata on both sides, have been pierced and blasted in a great many places, and considerable quantities of the rock removed, for the purpose of ascertaining its quality and depth, and the nature of the ground beneath. The rock of the dam is considerably harder, as well as thicker, than what is found on either side, but the whole is soft and easily pierced and broken. It appears to be a sandstone of a soft description, and generally in an advanced stage of decay,

varying in thickness from one and a half to four feet, and resting on a bed of rough gravel. It is hardest at the surface, and becomes softer and coarser towards the bottom; which last has more the appearance of indurated gravel than of rock. The rock to the north and south of the dam seldom exceeds one and a half or two feet in thickness, and is in a very decayed state.

The several strata are found in their natural position on the island of Ramisseram and on the opposite coast; and a number of wells having been sunk through them by the inhabitants, the quality and thickness of the rock are easily examined there, and correspond exactly with the preceding description.

In the dam there are two channels, one about five hundred yards from the eastern end, which is termed the large channel or river, and through which alone vessels at present pass. The small channel is three hundred yards from the west end of the dams; it has only three feet of water on it, is very narrow and full of rocks, and is in consequence only used by canoes and boats. The principal passage is about fifty yards broad, and is of very irregular depth, with a rocky bottom. In some places it is not more than two and a half feet deep at low water; but there is a very winding narrow channel through it, just sufficiently broad for the passage of a dhoney, and nowhere less than five and a half feet deep at high water, ordinary tides. This channel, from its very winding course and little depth of water, is exceedingly inconvenient, and occasions great delay and considerable expense to vessels passing through it. There is often a rapid current and heavy swell, and, unless in very moderate weather, no vessels drawing more than four or four and a half feet of water venture through it; and in rough or stormy weather it is often, for several days, altogether impassable.

The passage has always been confined to dhonies and other small vessels, chiefly belonging to the native merchants. These, when coming from the northward, anchor eleven or twelve hundred yards from the east end of the dam, in sixteen feet of water, soft mud. There they unship cargo till their draught of water is reduced to four or five feet, according to the state of the weather, and then drop or warp through the channel, as the wind or current are favourable or otherwise. After passing the channel, they anchor a second time, about four hundred yards below the dam, in twelve feet of water, and re-ship cargo till they draw about six feet. They then proceed to the southward, and cross the sand-bank already referred to, about 2700 yards below the dam, and on which there is not more than seven feet of water when the tide is full. As soon as they cross the bank, they anchor for the third time, to re-ship the remainder of the cargo, and then continue their voyage. These operations usually occupy

three or four days, even under the most favourable circumstances; when the weather is stormy the detention is considerably greater, for the pilots will not then undertake to carry any vessel through the passage; and if this happens during the north-east monsoon, the vessels are obliged to remain at anchor, to the north of the dam, in an open situation, exposed to the risk of being driven on the rocks to leeward. Moreover, when ten or twelve dhonies arrive together, which is often the case, the last are occasionally detained for a very considerable period; for as they can only pass when the weather is moderate, and then only three or four during one tide, owing to the crookedness of the channel, it may happen that the whole number are unable to get through while the wind and sea continue moderate, and the last arrivals are obliged to wait ten or twelve days longer for another interval of fine weather.

The expense attending the passage of the channel, and the bank below it, varies from ten to forty rupees, according to the size of the vessel; and when the detention and risk of damage are taken into the account, the whole must form a heavy burden on the coasting trade of the country, and greatly retard its extension and improvement.

The removal, therefore, of the existing difficulties and obstructions, and the improvement of the channel, so as to facilitate the passage of the vessels which now use it, and at the same time to admit of its being navigated by ships of a larger size and superior description, is an undertaking of much importance, and highly deserving of attention.

From the preceding remarks, and from an inspection of the chart, it will be seen, that the removal of the rock which obstructs the channel, though that alone would be an improvement of much value, would not remove the whole of the difficulties at present experienced in navigating the Paumbum Channel; for after passing through the rocks, there still remains a sand-bank to be crossed, on which there is not more than seven feet of water at high-water, ordinary tides. The removal of this bank, it is to be feared, may prove a very difficult part of the undertaking; at all events, the success of any measure adopted for the purpose is much more uncertain than if rock formed the obstruction, for where that is met with, its removal can always be calculated on with certainty, though the expense may in some cases be great. The bank, it is probable, consists chiefly of the earth and sand which composed the narrow neck of land that formerly connected the main land and island of Ramisseram, and of the sand washed out of the deep channels beneath, and to the south of the dam, by the rapid currents over it and through its openings. On the

breaking up of the stratum of rock which formed the junction, the loose sand on which the rock rested, and which was protected by it, would, on being uncovered, be swept away by storms and by the rapid currents flowing through the openings and interstices among the broken fragments. These currents, after passing the rocky barrier and reaching the open space to the south, spread and lose their velocity, and being at the same time met by opposing currents from the east and south-west, the sand washed from among the rocks is deposited in the place now occupied by the bank, where the water is comparatively still and smooth, being protected to the north by the dam, and on the south side by a chain of small islands.

The stream through the principal opening is extremely rapid at times; and as soon as it escapes from the rocks, and reaches the soft sandy ground, it has, as will be seen, scooped out for itself a deep and extensive channel, to the distance of upwards of a mile and a half. The sand from this channel, thus thrown up and deposited at its sides, and also to the southward, where the stream by spreading and meeting with opposing currents loses its rapidity, has no doubt contributed to the formation of the bank. It does not appear, however, that this is now subject to any material alterations or changes; the pilots state, that the depth of water has not altered within their memory, as far as they can judge; and the irregularity of the soundings, which often vary from one and a half to two feet in a very short distance, together with the quality of the bottom, show that the sand is not frequently shifting as at Adam's Bridge. Nor does there seem to be any reason for considerable changes. The bottom of the sea to the north is either rock or clay, and the currents from that direction appear to bring very little sand with them, for the water, during the north-east monsoon, is usually clear and free from mud or sand. Storms may produce material changes, and probably do; but whether these are permanent or not, there are no means at present of ascertaining.

A careful and attentive examination of the whole of the channel, between Paumbum and Point Ramen, suggests the three following plans for its improvement:—

1st. The present principal opening through the dam may be cleared of the rocks which obstruct it, and straightened, without increasing its depth.

2dly. The same opening may be deepened to eight and a half or nine feet at high water, ordinary tides; or another channel may be opened, of the same depth, in some other part of the dam, if considered more expedient. Or,

3dly. A channel, twelve or fourteen feet deep at high water,

may be formed, either through the dam or through the projecting point of land on the Ramnad coast, at the distance of about two miles west of Point Ramen.

1. From the description that has already been given of the channel through which the dhonies now pass, it will be evident that much difficulty and delay must have arisen from the crooked and winding shape of the channel. There were several turns in it, and one in particular where the current is the strongest, which increased the difficulty very much; and frequently, when the weather was rough, interrupted the passage entirely for several days at a time. It will be satisfactory to Government to know that these obstructions have been all removed by the small working party which was authorized to be employed for the purpose of assisting in the examination and survey of the passage, and the channel rendered quite straight, and also a little deeper than it was formerly. Dhonies now pass through it quickly, using only one warp instead of three or four, as they were obliged to do before the rocks were removed; and one or two keeled vessels, drawing about six feet of water, have sailed through. This alone is a very considerable improvement, for it will prevent much of the detention to the north of the dam, which has hitherto been unavoidable, and was always attended with danger; and will at the same time admit of vessels passing through, drawing a little more water than formerly, by enabling them to pass at high water when the tide is quite full. The party continues at work in the channel, and may be expected still further to improve it before the work is stopped by the monsoon.

2. The second plan, namely, opening a channel eight or eight and a half feet deep through the rocks, may be accomplished, I think, with most ease and least expense, at about thirteen hundred feet from the west end of the dam, where, it will be observed from the chart, there is seven and a half and eight feet of water, near the main dam on the north side, and within one hundred yards of it on the south side. The quantity of rock, therefore, to be removed, to obtain a channel of that depth, would not be very great, while, in its removal, much comparative facility would be experienced, in consequence of there being very little current or swell to interrupt or retard the work. For the main dam at that place is tolerably compact and entire, and there is consequently very little current in its vicinity. By allowing a part of the main dam to remain till the last to obstruct the current and swell, and by completing the channel on both sides before its removal, the greater portion of the work would be performed in comparatively smooth water, which is of very great consequence in blasting and weighing rock. The narrow part of the channel would also then be very

short, not exceeding one hundred and fifty or two hundred yards in length, which would be a great advantage to vessels.

The objections to it are, that the anchorage and channel would be more exposed to the strength of the wind and swell during the north-east monsoon than the present channel, which is sheltered, in some degree, by the west end of Ramisseram; and being farther removed from the eastern shore, the pilots would have more difficulty in communicating with vessels, and affording them assistance in stormy weather.

On the south side of the dam there is a projecting point of the sand-bank between the proposed place and the deep channel opposite to the principal opening, on which there is not more than from five and a half to six and a quarter feet of water at low tide. If this were to remain in its present state, vessels, after getting through the channel during the north-east monsoon, would be obliged to pass round the head of it in a direction across the current, which would evidently be attended with considerable difficulty to dhonies and country craft. But as this point of the bank is nearly in the direction which the stream through the new channel would take, it would, I have not the slightest doubt, be entirely swept away on the opening of the channel, for it seems to owe its existence to the absence of any strong current or stream in that part, in consequence of the compact quality of the dam there. The only real objection which I can perceive is its greater distance from the shore, and consequently greater exposure to the wind and swell during the north-east monsoon.

To deepen the present channel to the same extent would be a much more tedious and difficult undertaking. There, it will be seen, the shallow water extends to a much greater distance to the northward, for at six hundred yards from the dam the depth is only six and a half feet at low water. To obtain a channel of the desired depth, it would be necessary, therefore, to excavate and deepen not less than seven or eight hundred yards in length; while, at the former place, the distance does not exceed two hundred or two hundred and fifty yards. The difficulty of the operation also would be increased in a very great degree by the distance from the dam, the heavy swell which often prevails, and the rapidity of the currents. These causes would retard the progress of the work very greatly, and raise the expense proportionally, for where there is a heavy swell or rapid current, it is impossible either to blast or weigh the rock.

A large proportion of the space to be deepened, it is true, does not appear to consist of solid rock, but of fragments of rock and stones firmly fixed in sand or gravel, and covered with weeds. It is probable, from the appearance of the adjoining beach and

land, as has been already observed, that no large masses of rock would be found at a greater distance than one hundred and fifty or two hundred yards to the north of the dam, and that beyond that line the bottom consists of small pieces and fragments of rock, carried there originally by the current, and now firmly fixed in hard gravel and sand. These, generally, it would be unnecessary to blast, as, it is presumed, they are not too large to be weighed entire; but still much difficulty and inconvenience would be experienced in loosening and removing them, in an exposed situation, with a heavy swell, and in five or six feet of water. The bottom appears to be too compact and rough to be cleared and deepened by dredging, or by any similar means procurable in this country. A diving-bell sufficiently large to admit of two or three men working within it, with short iron crows and pickaxes, might be employed with great advantage, and would be highly useful. Divers, of whom there are great numbers in the vicinity, might also be used to assist in loosening the fragments with the same instruments, and afterwards in raising them into boats or catamarans, either with the hand or with windlasses, as circumstances might require. An operation of this kind, subject too, as it would be, to frequent interruptions from rough weather, would evidently be very tedious and expensive, and could not be completed probably in less than two or three years. But of its success I think there is no reason to entertain any doubt, and it certainly would be a vast improvement. It would be more convenient and useful than a channel of the same depth at any other place; and there would be this advantage attending the plan, that to whatever extent the improvement might be prosecuted, whether continued to its full accomplishment or stopped at any intermediate stage, no part of the work, if judiciously conducted, would be thrown away or prove useless, but all that might be performed would, in some respect or other, be beneficial.

The only objection is the expense, which would be at least three times as great as the cost of a similar channel at the place already mentioned.

The advantages to be derived from an eight and a half or nine feet channel through any part of the dam would be very important. Many of the smaller dhonies would be able to pass through at once without any detention, and the inconveniences and delays now experienced by the larger vessels would be greatly reduced. They would have to unship a comparatively small portion of their cargo, and when sufficiently lightened, would be able to pass through in almost any weather, and reach a perfectly safe anchorage, instead of being detained in a very exposed and dangerous situation.

What effect the improvement of the present channel to the

extent here contemplated, or the opening of a new one, might have on the sand-bank to the south of the dam, it is impossible to foretel; but that a considerable change would be produced appears to me very probable; and if the increased stream and currents were taken advantage of, and judiciously directed, it is not unlikely that the passage across the bank might be considerably deepened. But this forms no necessary part of the plan now under consideration, though, in the event of its being adopted, this branch of the subject ought to be carefully attended to; for without a very material change in the sand-bank, the navigation of the straits, if the channel is made through any part of the dam, must remain very imperfect, and be confined chiefly, as it now is, to country vessels.

3. The third plan is to open a channel twelve or fourteen feet deep, either through the Paumbum Dam, or, if it should be thought more advisable, through the promontory on the Ramnad coast. To form a channel of that depth through the dam would be a very expensive and exceedingly laborious undertaking. The length of the cut would be upwards of twelve hundred yards, with an average depth of four feet to be excavated. The labour of blasting and weighing rock, when the depth of water exceeds eight feet, is very great indeed, and almost impracticable, except in very smooth water. At the distance of eight hundred yards from the dam, the swell, during a great part of the year, is very considerable, and would add much to the expense and labour of the work, for it could only proceed there during very moderate weather, and would be liable to constant and tedious interruptions.

Of the whole extent, perhaps not more than half would be found to consist of rock requiring to be blasted, and the remainder of fragments of various sizes mixed with gravel or sand, a considerable portion of which, it might be expected, would be swept away by the currents, on the removal of the rocky ledges or beds which now protect them. Still the labour would be very great and extremely tedious, and the undertaking would require several years, probably not less than five or six, for its accomplishment. But even if the channel were completed to the proposed extent, I think it very doubtful whether the northern part of it would not be liable to fill up again. For on the north side, at the distance of eight or nine hundred yards from the dam, the current is not, I think, sufficiently strong to keep such a channel clear, and the influence of the stream through the enlarged opening of the dam would scarcely extend to so great a distance.

The plan would also be incomplete without the removal of part of the sand-bank to the south of the dam, or a considerable improvement at least in the passage across it. This, it has already been stated, is uncertain under any circumstances, though I think

the increased quantity of water and force of the stream which so extensive an enlargement in the opening through the rocks would produce, would contribute very materially to any measures that might be undertaken with that view.

Though at first sight the bank appears to resemble very much the bars which are formed opposite to the channels through Adam's Bridge, still I think it is essentially different from them. As far as can be judged, it is permanent, and not liable to shift; and the principal causes which formed it, have, it seems probable for the reasons assigned in a preceding part of the Report, long ago ceased to exist, or at least now act in a very inferior degree. The bars opposite to the channels through Adam's Bridge are most extensive on the south side, and are thrown up by the very high surf and heavy swell produced by the south-west monsoon, which acts with great force on the south side of the bank. But at Paumbum, the space immediately to the south of the dam, where the bank is situated, is protected from the violence of the south-west monsoon by the range of islands to the south of it, which form a complete barrier, and comparatively little swell or surf is ever experienced there. Any alteration produced in the bank would, in consequence, be the more likely to prove permanent; and I think that the current and stream might be so directed, by means of stone bulwarks or jetties, as to produce a very great improvement.

But this plan, on the whole, appears to me much too laborious and expensive, and at the same time attended in several respects with too much uncertainty, to be advisable; and if a twelve or fourteen feet channel be considered absolutely necessary, I would recommend, in preference, that it be opened through the promontory of the main land.

In 1814 there was a very severe storm or hurricane at Ramisseram, during which the sea broke over the land in many places, and at about two miles from Point Ramen cut a channel completely across it. A ledge of rock on the south side of the land was destroyed and swept away, and a pit excavated seven or eight feet below the level of the sea for a distance of two hundred yards, from the end of which to the north shore the bed of the channel is three or four feet above the level of the sea. The gale from the northward lasted only about four hours;—had it continued a few hours longer from that direction, it is probable that there would have been a deep channel formed entirely through the land, though, most likely, it would not have continued open for any length of time, for the surf which breaks on both shores, but particularly on the south side, with considerable force, not being counteracted by a sufficient rise and fall in the tide, would probably, in a short time, have filled its ends with sand.

The breadth of the land here is seven hundred and twenty-eight yards. It consists chiefly of loose sand, with a little soft decayed rock mixed with it in some parts, which is easily broken with the hammer and pickaxe. On the north side there is a reef of coral, not solid or connected, but in detached masses, and of no great breadth, for at four hundred yards from the shore the water is fourteen feet deep. On the south side the water deepens very rapidly, the depth at one hundred yards from the shore being two and a half fathoms. A channel twelve or fourteen feet deep might, therefore, be cut here with comparatively little difficulty, and at a moderate expense; and being to the south, and entirely clear of the bank beneath the Paumbum dam, the removal of that bank, or a passage across it, would form no part of the undertaking. It is probable, however, that the channel would not remain open without some contrivance at its ends to prevent the surf from filling them up with sand; and this would, it is to be apprehended, be the most expensive and uncertain part of the project.

The easiest and most likely way to effect the object would, I think, be to carry a double bulwark of large stones from both shores, in a continuation nearly with the sides of the channel, into deep water, beyond the influence of the surf. The ends of the channel thus terminating in deep water, it does not appear that any cause would exist there to fill them with sand, for they would be beyond the reach of the surf, and there are no currents likely to produce that effect. It is probable that very little sand would enter the channel, and that whatever did enter would be swept away by the current through it, which, at all seasons of the year, would be considerable. The principal danger to be apprehended is the formation of a sand-bank to the south of the channel, or bars opposite to its ends, as occur before the natural openings in Adam's Bridge. This apprehension is perhaps not entirely without grounds, but if, on the completion of the channel, any symptoms of either a bank or bar should appear, I think the formation might be entirely prevented by constructing a second bulwark of stones in front and perpendicular to the ends of the first bulwark, at one hundred or two hundred feet from them. This narrow opening between the two bulwarks would be swept by the south-west monsoon and currents produced by it, which would most likely keep it always deep and free from sand. On the north side there is much less danger of any banks forming, for there are none opposite to the Paumbum channels, and the sea beyond the rocky ground is clear and free from obstructions of every kind.

After fully weighing all the advantages and risks attending the opening of a channel twelve or fourteen feet deep at this place, I think there are good grounds for considering the undertaking to

be practicable; but in deciding on the expediency of adopting or rejecting it, it is necessary to take into consideration the possibility of a partial or complete failure, for the project is so entirely new, and so unlike any thing that has hitherto been undertaken in India, that no comparison can be made with the result of other works of the same kind, and no information, therefore, drawn from experience; while, at the same time, the nature of the currents, their strength and direction at different seasons of the year, and the manner in which they are affected by the opposite monsoons, are all, in a great degree, still to be learnt.

Respecting the expense of the different projects, from what has already been said it will be evident that much uncertainty must necessarily exist, and that it is impossible to form any thing like even an approximation to a correct estimate. The expense will depend greatly on the seasons being favourable or otherwise; on the exact quality and nature of the ground beneath the surface at the place where the channel may be opened; on the currents, and the effect they may have in accelerating the operation by sweeping away the sand and loose soil when the solid rock is removed, or retarding it by producing, in some cases, a contrary effect; and on a thousand other circumstances which it is impossible to foresee, and which can only be discovered as the work advances. In the present state of our information, a general plan or course of proceeding only can be laid down, which will be liable to constant changes and modifications; and whichever of the projects that have been suggested may be preferred, it will be necessary to leave a great deal to the discretion and judgment of the officer who may be entrusted with its execution, not only as to the manner of proceeding with the work, but also the means to be used, the expense to be incurred, and the extent to which the undertaking may be carried with advantage. The following sums must, therefore, be considered as very rough guesses only, which may exceed or fall short of the actual cost to a very considerable extent:—

The plan of opening a channel eight or nine feet deep and fifty feet wide through the dam, at about thirteen hundred feet from its west end, may be calculated at 70,000 rupees (7000*l.* sterling), and two seasons would probably be required for its completion.

Deepening the present channel to the same extent cannot be estimated at less than 150,000 rupees (15,000*l.* sterling), and probably three years would be required to complete it.

The practicability of opening a channel twelve or fourteen feet through the dam, and of keeping it open, appears to me so uncertain, with our present knowledge, that it cannot with propriety be recommended, and it is unnecessary, therefore, to consider its expense.

Cutting a channel through the main land, where the sea made

a breach in 1814, would cost probably from one and a half to three or four lacs of rupees (15,000*l.* to 40,000*l.* sterling), according to the nature and extent of the works that might be required at its ends to prevent them from filling up with sand; and an equal uncertainty of course exists with respect to the time required for the performance of that project.

From a review of the several plans that have been proposed, it will appear, I think, that if a channel of eight or nine feet through the rocks be required, without reference to the removal of the sand-bank to the south, or the improvement of the passage across it, the most advisable place for such a channel is at about thirteen hundred feet from the west end of the dam.

If it should be considered expedient to confine the operations in the first instance to an eight or nine feet channel, but to keep in view the chance of extending the depth afterwards to ten or twelve feet, if circumstances and experience should justify the measure, it is probable that deepening the present channel would be the most desirable and safe way of prosecuting the undertaking. Though much more expensive, it is the more certain, and the channel would be in the most convenient situation.

The removal of the rocks which obstructed this channel have altered it considerably since it was inspected in last March, and in some places the layer or crust of rock which covered its bottom has been entirely removed. It is extremely desirable that the effect of one north-east monsoon should be seen on the channel in its altered state before any final conclusion is come to respecting its comparative merits and defects with those of the proposed new channel near the west end of the dam. If there is only a covering or crust of rock, as there seems every reason to believe, the rapid current through the channel during the north-east monsoon may, as that is now removed in several places, produce considerable alterations, not only on the channel itself, but on the ground to the north and south of it; and this it is highly desirable to ascertain before the expediency of improving or abandoning the channel is decided.

If a channel of twelve or fourteen feet is considered an object of sufficient importance to warrant the attempt, under the uncertainty which now exists with respect both to success and expense, and the imperfect state of our knowledge on the subject, I think the plan of opening a channel across the main land, where the sea broke over in 1814, ought to be adopted.

The best seasons for working, whatever plan is preferred, as far as can be judged from the experience of the present year, are from the beginning of March to the middle of May, and from the end of August to the commencement of the north-east monsoon. There are occasional intervals of fine weather in the months of

February and August, which might also be taken advantage of; but more than four or five months in the year cannot be calculated on for carrying on the work with advantage. The sea appears to be smoothest, and least affected by currents, from the beginning of September to the middle of October, and during that period the improvements to the north of the dam or promontory ought to be executed; for, in the north-east monsoon, the water there is generally too rough to admit of the work being prosecuted with much success. In the months of March, April, and May, the rocks to the south of the main dam might be removed.

The process of boring and blasting rock under water was readily learnt by the small party of pioneers employed on the survey, and after a little practice was conducted with much success. In blasting the rock previously to removal, jumpers, six inches in diameter*, were generally used and found most efficient. They were worked by three men at a time, on a low raft formed of two large canoes, lashed together, and covered with loose planks. After a great number of experiments with different quantities of gunpowder, charges of from four to six pounds were thought to produce most effect, and were usually employed. The rock was bored quite through, the object being to separate and displace the fragments completely, and the charge was covered with gravel and small pieces of rock and coral. The gunpowder was fired in the usual manner by means of tin tubes. The large fragments were weighed by means of a common country boat, furnished with a windlass, derrick, and tackle. Slings, made of strong rope, were placed round the fragments by divers; to these the tackle was made fast, and in this way pieces of rock, three tons in weight, were occasionally raised into the boat. The apparatus was very imperfect, the flat boat and the small supply of timber sent from Madras, for this part of the operations, having been lost on the way down to Ramisseram; and the only substitutes procurable on the spot being a clumsy country boat and some drift timber. The small pieces of rock were brought up with the hand by divers.

The most convenient and expeditious apparatus for weighing and removing the fragments of rock in fixture, would perhaps be a large flat boat, partly decked, furnished with a double set of derricks, windlasses, and tackles, so arranged as to be used at the same time on opposite sides or ends of the boat. To save the necessity of raising the fragments into the boat, which was found very difficult, and attended with much delay, there ought to be three or four double canoes with decks, to receive the rock, and convey it to the places where it is to be deposited. There would then be no necessity for changing the situation of the weighing-

* Sic in MS.

boat when once placed, till all the broken rock within its reach was removed, which is a point of much importance, for it was found a very troublesome and dilatory operation to fix the boat in the right spot when there was much current.

The canoes of the boring rafts ought to be decked, to prevent them from filling with water and sinking, which they are very apt to do when there is any considerable swell.

A diving-bell, which might be made at Madras, would be of great use for examining the bottom, and fixing the most convenient places for blasting. The divers, it was soon found, could not be safely trusted with this; they usually directed the jumper to the first rock they happened to meet with, and frequently caused the same rock to be bored several times, which occasioned the loss of much time and labour, and left the rock imperfectly broken, and in a very unfit state for further blasting. Much depends on the selection of the points for boring and blasting, and a diving-bell would enable the officer in charge of the work to regulate this part of the operation himself.

When the water was tolerably smooth, and the current not strong, very little difficulty was experienced in blasting and weighing rock at the depth even of eight feet, but when there was any considerable swell, or a rapid current, it was impossible to proceed with the work: hence the great advantage, in respect both to time and expense, in selecting such a situation for the channel as will afford smooth water for the longest periods.

In conclusion, I beg to observe, that it would afford me much satisfaction if Government, previously to adopting any of the preceding plans, or coming to any final resolution on the subject, would be pleased to forward to the Honourable the Court of Directors, for the purpose of being submitted to experienced civil engineers in England, copies of the charts of the straits, and of all the information which has been collected during the late survey. The improvement of the navigation through the Manar Straits is an object of so great value and importance to Indian commerce, and so much depends on the choice of place and on the means to be used, that every precaution ought to be taken to obtain the best possible advice on the subject; and a delay of a year or two is of little consequence, when compared with the advantages which might possibly be derived from the opinions and advice of engineers in Europe who have been employed on similar undertakings.

If this suggestion should meet with the approval of the Right Honourable the Governor in Council, I would further beg to propose, that the papers should be entrusted to the care of Captain A. T. Cotton, who, it is likely, will be obliged to proceed to England in January for the benefit of his health, and who, having

been employed at Paumbum during the whole of the survey, and having had the immediate charge and direction of the experiments, will be able to afford information on many points which cannot be sufficiently explained by either charts or reports.

Pending the reference to England, I would recommend that the observations on the passage should be continued, and that the present party of pioneers, increased to fifty men, with some ship lascars and divers, should be employed under the direction of an engineer officer in the improvement of the present opening, and in making some experiments on the bank to the south of it. Whatever the final decision may be respecting the more extensive improvements, the labour of such a party cannot fail to be very beneficial, while the expense would be inconsiderable, and much valuable information would be obtained, which would be highly useful in the event of the prosecution of the work afterwards on an extended scale.

It is due to Captain A. T. Cotton and Lieutenant F. Cotton, to mention the valuable assistance offered by them in the performance of the duty at Paumbum, &c.

(Signed) —— Sim,
Inspector-General of Civil Estimates.

II.—*Journal of a Voyage up the Massaroony in* 1831. By William Hilhouse, Esq., of Demerara, Corresp. Memb. R.G.S., London. Communicated by the Author. Read 23d December, 1833.

In 1801, an expedition was sent from Demerara up the Essequibo, to communicate with the Portuguese, through their post on the Rio Branco ; and to endeavour, if possible, to stop the Indian slave-trade, which had been heretofore carried on by the Caribisce in that vicinity, whence both Demerara and the Rio Branco had before received their supply of Indian slaves Dr. Hancock, since well known in the scientific world, was the most ostensible individual employed on that mission; and it is much to be regretted that he has furnished us with no public account of his observations on his interesting journey. His route, it is true, had been several times traversed before, as it has been since ; but it was desirable, if possible, to get a few points of latitude and longitude to determine, at any rate, the course of the Essequibo. And the rough map which he compiled of his progress, only gives comparative distances, and lays down the points of entrance of the great tributaries; from which it appears, that, after the junction of the Rippanoony, the Esse-